Measuring the success and cost effectiveness of New Zealand multiple species projects to the conservation of threatened species

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Abstract

Much attention is focused on conservation efforts to protect and recover threatened species. As part of these efforts, many projects attempt to manage sites containing populations of more than one threatened species. Evaluation of those multiple species projects is essential to determine their success and cost effectiveness in the conservation of threatened species. In this paper we report on the further development of the Cost Utility Analysis technique, previously tested on single-species programs, to the evaluation of multiple species projects. The results of tests on six New Zealand projects show that Cost Utility Analysis can determine the species conservation success and cost effectiveness of a range of different multiple species projects. The four projects that manage a high proportion of the total population of a threatened species were the most successful in terms of improving the conservation status of species. The Present Value cost per unit of output for each project ranged from NZ$425 000 to more than NZ$19 million. This research finds no evidence for the proposition that multiple-species projects are more cost effective than single-species programs in the conservation of threatened species. Multiple-species projects may, however, have other outputs, such as advocacy and education, or ecosystem restoration that are included in their objectives and are, as yet, unmeasured. The versatility of the Cost Utility Analysis technique provides further support for its use both in New Zealand and internationally for the evaluation of both single species programs and multiple-species projects.

Introduction

The recovery of threatened species is costly. Annual expenditures on threatened species programs are US$20 million in New Zealand (DoC 2001a), US$280 million in the United States (Dawson & Shogren 2001), and US$6 billion globally (James et al. 1999). James et al. (1999) estimate that global expenditures of US$22.6 billion per annum will be needed to protect 15 percent of global land area as natural reserves. The case for expenditures of this magnitude is predicated upon the belief that they will be both sufficient and effective in preventing species extinction and biodiversity loss. Whether support for the first requirement is justified is dependent upon the success and cost effectiveness of species conservation efforts. This is largely an empirical question, but one that is rarely tackled despite the often very large expenditures already occurring.

While much attention has focused on single-species projects and programs, increasing interest and effort has been directed toward multiple-species projects. Multiple-species projects can spread expenditures over several species and may provide a lower cost way to manage threatened species than do single-species projects and programs (Tear et al. 1995). That possibility can be tested by measuring the success and cost effectiveness of multiple-species projects, and comparing those measures to the results for single-species projects and programs.

For expenditures on threatened species to be successful, they must produce some outcome in terms of the conservation of threatened species. There is, however, very little tangible evidence available to show that expenditures on threatened species projects are successful. A fundamental issue to be confronted is how to measure the success of threatened species projects. A recent paper considered this problem and concluded …'It was not possible to find an unbiased, objective metric for measuring effort put forth in recovery actions and to track relative success. At this time, in fact, many recovery management actions cannot be determined to be successful or unsuccessful' (Abbitt & Scott 2001: 1281). We report in this paper on the Cost Utility Analysis (CUA) technique we have developed to measure conservation effort put forth in protection and recovery actions, and to track the relative success of those actions.

Cost Utility Analysis (CUA) has been applied in some earlier studies to single-species projects (Cullen et al. 1999; Cullen et al. 2001). In this paper we demonstrate how CUA has been further developed to align the measurement scale with the internationally usable IUCN Threat Categories. We report how we apply the technique to multiple-species projects and provide empirical results on the relative success of six New Zealand multiple-species projects in recovering threatened species and preventing biodiversity loss. Those results are subsequently compared to similar measures for single-species programs to determine whether multiple-species projects provide more effective and lower cost recovery of species.

Evaluation of threatened species projects

Many researchers from a range of disciplines, including biology and economics, have tackled evaluation of threatened species projects. A recent review of this literature is provided by Hughey et al. (2003), who outline the wide range of approaches applied to evaluation of conservation efforts. A major conclusion of that review is the absence of empirical evaluations of real world threatened species and biodiversity projects. Much evaluation literature written by economists focuses on hypothetical projects including how to maximize habitat selection with a finite budget. The evaluation literature written by biologists focuses on population numbers, genetic uniqueness and other biological features, but neglects the contribution that can be made from economic analysis.

Our focus is on the success and cost effectiveness of multiple-species projects because managers in New Zealand are required to be cost effective in preventing, and mitigating the causes of species extinction and biodiversity loss (DoC 2001b). Determining success and cost effectiveness requires quantifying both the inputs used and the outputs produced by these projects. The quantity of inputs used in threatened species projects can be measured using data on the costs of inputs. Measurement of costs requires care in identifying the appropriate costs to include, but so long as there are adequate accounting records for projects, this is a straightforward task. Where they are relevant the costs can include the opportunity costs of resources foregone because of the threatened species project. Measurement of the success of biodiversity projects appears more complicated, and success at preventing extinction of species is rarely measured, but is achievable. Our focus for measuring success is the conservation status of threatened species, compared to a counterfactual of their conservation status in the absence of the management provided by the project.

Cost Utility Analysis was developed more than thirty years ago to overcome a similar challenge in evaluation of 'human health projects' (Drummond et al. 1997). Projects have goals, and the contribution of projects can be measured by the extent to which they achieve their goals. Human health projects have objectives - overcome infection, suture the wound - but the fundamental goal is to improve human health, and maintain it at a higher level than it would otherwise be. Progress toward the goal can be described on a scale from 0.00 (death) to 1.00 (complete health). CUA is used to evaluate health projects by rating a patient's health status at regular intervals if medical intervention occurs, and comparing those ratings to a counterfactual, what their health status ratings would have been over the same period of time without medical intervention (Drummond et al. 1997). In these studies the counterfactual typically is 'no change' in health status. The unit of measurement in these health evaluations is Quality Adjusted Life Years (QALY). The total measured output from a health intervention, measured in QALY, is the sum of the 'with intervention' health status ratings minus the 'without intervention' health status ratings over the chosen study period. A health intervention, for example, which improves a person's health status rating from 0.6 to 0.9, and which maintains that health status rating for ten years, produces (0.9-0.6) x 10 = 3.0 QALY.

Biodiversity projects also have proximate objectives – reduce the numbers of predators, increase the area of habitat – but the fundamental goal is to conserve threatened species. Cost Utility Analysis can be used as a technique to measure the success of a project in achieving that goal. Cullen et al. (2001) explain how CUA has been adapted to quantify the success of New Zealand single-species projects and programs in improving the conservation status of threatened species using a unit of measurement named Conservation Output Protection Years (COPY). In this paper we report on how we have improved the technique, and show how success in terms of the conservation status of threatened species can be measured from multiple-species projects.

The Cost Utility Analysis approach measures the success of biodiversity projects by comparing the conservation status of a species over time 'with the project' to what the species status would have been over time 'without the project'. Note that conservation of species involves a time dimension – the goal is continuing better status of the species, not just better status at one moment in time. The approach requires annual conservation status ratings for species, for each year of the chosen study period. A project is successful if there is a difference between annual conservation status ratings of a species 'with the project' and the species' annual conservation status ratings 'without the project'. Projects that successfully improve and maintain the conservation status of a species, when the base case would have been no change in status, or more frequently, a decline in status (DoC & MfE 2000a;

DoC & MfE 2000b; Abbitt & Scott 2001), produce significant conservation benefits. Projects that do not improve the conservation status of a species from their 'without the project' status do not make a contribution to threatened species conservation. Biodiversity projects may also have other goals, such as protection and restoration of ecosystems, development of management techniques, control of predators and pests, and advocacy and education. The overall success and cost effectiveness of a project should be evaluated in terms of all of their stated goals. In this paper, however, we focus on the success and cost effectiveness of projects in terms of conserving species as this is the fundamental goal of threatened species projects.

The measured annual contributions of a conservation project should be discounted before they are compared to the discounted costs of the project. Discounting of conservation output recognizes that there is a risk of extinction through stochastic events, and this risk will be greater the longer a species takes to recover. Hence timing of improvements in species' conservation status is important and discounting of the COPY produced is completed to achieve commensurability of outputs from each year of the project. Selection of an appropriate discount rate is often contentious and we evaluate the sensitivity of our results by using a range of discount rates in the empirical section of the paper.

Methods

A key requirement of the CUA technique is to find an appropriate scale for measuring the conservation status of species. Many countries and institutions have developed classification systems to describe the conservation status of species using a set of well-defined criteria (Molloy & Davis 1994; USFWS 1990; IUCN 2001). In practice, many of these systems place each species in a threat category such as 'Endangered' or 'Vulnerable'. The Department of Conservation (DoC) Threat Classification System (DoC 2001a) is linked to the IUCN (2001) red list, but recognizes some unusual features of New Zealand species and ecosystems, particularly the relatively small habitat area of some species, the small carrying capacity of those habitats, and the low population numbers of some species.

In previous research we used a seven category system to measure species status (Cullen et al. 2001). A species in one of the seven categories was then assigned the mean conservation status rating for that category using a linear scale, and a quadratic scale, both ranging from 0.00 to 1.00. The use of a categorical seven step scale reduces the precision of measurement of conservation output compared to the precision which can be achieved by using a continuous scale from 0.00 to 1.00. Use of a continuum from 0.00 to 1.00 allows for much greater accuracy in measuring changes in the conservation status of species than is possible with categories, as the status of most species changes only gradually over time.

To measure the conservation status of species we combined DoC's classification system with a cardinal scale to describe species status. We required project managers and species managers to estimate the status of a species on a continuum from 0.00 (Extinct) to 1.00 (Not Threatened) as illustrated in Table 1. The continuum is linked to the categories on the DoC (2001a) Threat Classification System and uses a quadratic scale which ensures that conservation status scores increase at a diminishing rate as a species moves closer to 1.00 (Not Threatened). The quadratic scale explicitly states that improving the conservation status of a species when it is critically endangered is a greater contribution to conservation than is improving its status when it is less threatened.

(Table 1 near here)

Project managers and species managers were asked to provide annual data on threatened species status over the study period for the project, ‘with the project’, and ‘without the project’, using the Table 1 scale. The projects vary in their year of commencement and hence the study periods range between 7 years and 14 years. We calculate for each year studied the (‘with the project’ minus ‘without the project’) scores to determine the annual output from the project. Our unit of measurement is Conservation Output Protection Years, COPY (Cullen et al. 1999; 2001). The (undiscounted) contribution of a project to the conservation of a threatened species present at a site is measured using the following equation.

$$COPYi = \sum_t (S_{itw} - S_{itw/o}) \qquad (1)$$

Where:

S_{itw} is species’ i conservation status in year t with management w

$S_{itw/o}$ is species i conservation status in year t without management w/o

A species management project, for example, which improves a species' conservation status from 0.30 (its 'without project' status) to 0.40 (its 'with project' status), and which maintains that status gap for ten years, produces (0.40 - 0.30) x 10 = 1.00 COPY. A second species management project, which prevents a species' conservation status falling from 0.36 to 0.24, and which maintains that success for eight years, produces (0.36 - 0.24) x 8 = 0.96 COPY. As noted earlier the annual 'with project' minus 'without project' scores are discounted using a range of discount rates when calculating the present value of COPY. We recognize that our measure is for a selected time period, and a project may deliver some conservation benefits after the study period, even if there are no further project expenditures. The size of these additional conservation benefits will be determined by the speed at which the species 'with project' status converges towards its 'without project' status.

For multiple-species projects, we add the (present value of) numbers of COPY produced for each threatened species identified by the project manager, to calculate the (present value of) total output from the project.

$$\text{Total Output} = \textstyle\sum_i \text{COPYi} \qquad (2)$$

A number of steps were taken to ensure the information on species status and subsequent calculations of numbers of COPY produced by each project were as accurate as possible. Project managers were sent a letter outlining the research project, and the technique to be used, a month before we visited them to obtain data on annual costs and species' annual 'with project' and 'without project' conservation status. All project managers were interviewed at least once, using a structured interview approach, between December 2001 and March 2002. Project managers have access to DoC's classification of species according to threat of extinction and are well informed of the status of the species found at the site they manage. Project managers could refer to the criteria listed in the Threat Classification System DoC (2001a), when determining where to place a species within a threat category. In several instances where populations of widely distributed species were present on a site, the site managers were unable to provide 'with' and 'without the project' scores for a species. In those instances we obtained data from the Recovery Team Leaders of the species in question. Information on the project costs was obtained from the project managers. They could access that information from the DoC financial reporting system.

The biodiversity projects

The New Zealand Biodiversity Strategy released in 2000 provides a twenty-year plan to halt the decline in New Zealand's native species (DoC & MfE 2000a). In December 2002 New Zealand had in excess of 2000 species classified as threatened (DoC 2002). By way of comparison there are 1,258 species listed as under threat in the United States (see http://endangered.fws.gov/wildlife.html#Species). The Biodiversity Strategy is funded by NZ$187 million of government expenditure

(NZ$1 = US$0.5095, December 2002) over its first five years (DoC 2001b) in addition to the annual expenditure on management services for protected species and island habitats. The US Fish and Wildlife Service estimated the potential direct costs from the recovery plans of all listed US species were about US$4.6 billion, or about US$2 million for each species (USFWS 1990).

Conservation of New Zealand's native plants and animals is one of the country's main environmental issues (DoC & MfE 2000), a view supported by the World Economic Forum (2002) finding that New Zealand's biodiversity performance is ranked worst of 142 nations. A principal reason for the rating is the very high percentage of endangered species in New Zealand.

New Zealand biodiversity has suffered from the introduction of exotic plant and animal species that predate, and outcompete many of the native and endemic species (Towns et al. 1997). Programs to control or eradicate introduced species are vigorously pursued to reduce the threats faced by many native species. As well, many offshore islands, which are free of predatory species, are used as sanctuaries for threatened species. In some cases small numbers of threatened species have been translocated to pest-free offshore islands as either temporary, or long term habitats (Kanze 2000). This strategy uses the surrounding sea to provide a barrier to reinvasion by pest species. Two obvious limitations to translocation are the number of pest-free offshore islands available in New Zealand waters, and the fact that there is no suitable habitat on islands for some species.

As an alternative, Mainland Habitat Islands have been developed during the past fifteen years (Saunders 2000; Saunders and Norton 2001). The DoC has designated six sites as Mainland Habitat Islands, and relies upon fences, topography, trapping and poisoning to control the numbers of pests at these sites. Mainland Habitat Island projects are expected to have four key features (Saunders 2000): they have ecological restoration goals; they involve intensive, multiple-pest control programs; detailed monitoring of the projects is undertaken; and they are expected to have relatively high costs and risks, as well as high returns. Mainland Habitat Islands are likely to be more costly than offshore islands as they do not have surrounding sea to provide a free, natural barrier to predators and competitors. Mainland Habitat Island projects have greater reporting requirements and hence more information is available on them than occurs for some offshore islands.

Offshore islands and Mainland Habitat Islands often provide sanctuary to multiple threatened species, and expenditures at these sites are likely to benefit multiple species (Cowan 1992; Towns et al. 1997). In some instances the threatened species managed at these sites may be umbrella species (Andelman & Fagan 2000), and a number of other species can benefit from expenditures targeted at one species. The challenge is to determine the output produced at these sites where multiple species are expected to benefit.

Results

Some key features of the six ongoing New Zealand projects studied are outlined in Table 2. Three of the sites are offshore islands and three are Mainland Habitat Islands. All projects have more than one threatened species present and are directed at conserving these species, as well as other project goals. Five of the six projects have a goal of protection and restoration of the ecosystem. Five of the projects have a goal of threatened species conservation, and the sixth, Rotoiti, has a goal of protecting native species and allowing their populations to recover. Not all expenditures at these sites are directed at improving the status of threatened species. At three of the sites, some expenditure is for public education and advocacy purposes. Managers of these projects were asked to provide a success rating for each of their project's stated goals. Those ratings are included in Table 2. These self-assessments can be compared to the results for threatened species conservation we report in Table 3. In the offshore islands projects, threatened species have been translocated to the sites for temporary or permanent sanctuary. The status of a site can be a constraint on the ability of a project to conserve threatened species. Legislation in New Zealand allows species to be introduced to Nature Reserves and Scientific Reserves but only allows re-introductions of species into National Parks.

(Table 2 near here)

Table 3 reports on the conservation status of each threatened species and the population of each species at the sites in the most recent year of the projects. Using equation 1 we have calculated the COPY produced for the threatened species present at each site and the output in terms of threatened species conservation for each project, and the results are shown in Table 3. A zero discount rate has been applied when calculating the numbers of COPY in Table 3. The effect of discounting of COPY using 0, 3, 6, and 10 percent discount rates are reported in Table 4.

(Table 3 near here).

We judge that COPY provides a valuable assessment of the success of a project but recognize that it is not the only possible measure of success for these projects. An alternative measure is the gap between a species 'with project' status score and its 'without project' status score in the final year of the study period. Equation 3 defines this measure which we term Gain.

$$Gain_i = (S_{ifw} - S_{ifw/o}) \quad (3)$$

Where:

Si_{fw} is species' i conservation status in year f with management w

$Si_{fw/o}$ is species i conservation status in year f without management w/o

We have calculated this second measure of success and the values for each species and each project are also reported in Table 3. It is apparent that the Gain values are considerably smaller in magnitude than COPY values for each species and for each project, but the relative success of the six projects studied is unchanged if we focus on the Gain scores.

It is well understood in New Zealand, and increasingly in other countries (Doerksen et al. 1998; USFWS 1990, Engeman et al. 2002), that threatened species projects incur significant annual management costs. Table 4 lists the Present Value of management costs of each of the six projects, measured in New Zealand dollars. These costs do not include the costs of habitat purchase that are the focus of many North American studies (Montgomery et al. 1994; 2000; Hyde 1989; Polasky et al. 1999). All six New Zealand projects are sited primarily on state owned land, and legislation prevents the land being available for other activities. There are no opportunity costs for the sites in the annual costs. There is however an annual capital charge calculated at 10 percent to the operational costs of projects, which is included to estimate total project costs. We report in Table 4 the Present Value (PV) of costs using discount rates of 0, 3, 6 and 10 percent, and the annualized cost of each project over the period we study. As reported in Table 2 the projects have differing commencement years. The level of expenditure can vary between years in these projects, and annualized costs are a useful way of describing the level of expenditure for each year of a project. All costs have been converted to 2001 dollars using the Statistics New Zealand Producers Price Index, Inputs, for All Industries. Each of the projects requires significant annual expenditure to plan, reduce pest numbers, monitor species, manage threats and other activities. Numbers of COPY produced by each project are discounted at 0, 3, 6, and 10 percent rates to allow calculation of cost effectiveness ratios in Table 4.

(Table 4 near here)

Discussion

Our principal goal is to measure the success in terms of the conservation of threatened species and the cost effectiveness of the expenditures for these six projects. We use CUA to evaluate progress towards a goal of improvement in the conservation status of species. Table 3 reports the conservation status in 2002 of the species studied, the percentage of the total population of the threatened species managed by each project, the non-discounted numbers of COPY produced per threatened species, and their GAIN scores at each of the six projects. There are very large differences in the measured output of these projects for the periods we study. Explanations for these differences in measured output may include variations in project life, proportion of a species' total population managed at the site, degree of threat facing a species, lifespan of a species, and the barriers to improvements in conservation status of a species including predation rates, low breeding success and long lifespans. Notably, the Little Barrier Island, Maud Island, Hurunui, and River Recovery projects have operated for seven or more years, include a large proportion of the total population of at least one short lifespan threatened species, and the first three of those projects have achieved significant success with at least one threatened species. In contrast the Tiritiri Matangi and Rotoiti projects provide habitat for small fractions of the total population for each threatened species present, and the projects have made small contributions to improving the status of those species compared to their status without the project. Recovery of some species often takes many years, but the Rotoiti project has been in operation for only five years.

Interpretation of the output data, the numbers of COPY produced for each species at a project, is aided by focusing on two species 'with the project' and 'without the project' status scores. The Black Stilt is a 'Nationally Critical' species that has made a small improvement over its 'without project' status as a result of the project. Project River Recovery has produced 0.07 COPY through management of the Black Stilt. In contrast, the Stitchbird is only an 'At Risk - Range Restricted' species throughout the project lifespan, but without the project its status would have steadily fallen to reach Chronically Threatened. The Little Barrier project has produced 1.39 COPY through management of the Stitchbird.

Table 4 reports the Present Value (PV) in NZ$ of expenditures over the life of the project, using four discount rates, and their annualized costs per hectare. Noticeably, the three projects with the smallest areas have seventeen times greater costs per hectare than do the three larger projects. Some explanations for these cost differences can be provided. Rotoiti and Tiritiri Matangi projects have multiple goals including advocacy and education and these activities significantly increase cost per hectare compared to projects that do not pursue those goals. Tiritiri Matangi, the smallest project area, costs fifty-six times more per hectare per year than does Hurunui, the largest project area. Only half of the Hurunui project area is actively managed, the remaining half is unmanaged to provide a control area. The annualized costs per managed hectare at Hurunui are shown in Table 4.

These projects require major investments each year and we can calculate the relative productivity of each investment by comparing measured output produced by March 2002, to the size of the total investment. Table 4 also reports Present Value of costs of each project, and PV per discounted COPY. To complete these calculations we assume that all project expenditures are ultimately attributable to species recovery efforts. It can be noted that choice of discount rate has little impact on the relative productivity of the six projects. There is a relatively small range in Present Value of the investments, but the wide variation in numbers of discounted COPY produced at the six sites plays the major role in determining the relative productivity of the projects. The Little Barrier Island project is the most successful at conserving threatened species. It is largely responsible for maintaining the Stitchbird in the Range Restricted category, when the counterfactual is a steady decline in its conservation status. Maud Island is the second most successful project and makes major contributions through the protection it provides for the Maud Island frog and the Striped gecko. Hurunui makes a major contribution to the management of Orange-fronted Parakeet. Project River Recovery provides management for the world's rarest wading bird, the Black Stilt. The Black Stilt faces a myriad of threats and progress is very slow in improving its status. As well as Project River Recovery, a Black Stilt program also manages this species and much of the Black Stilt's improvement has been attributed to that program. Tiritiri Matangi manages small though increasing percentages of the total populations of threatened species, hence it makes minor contributions to the species' status. Rotoiti provides habitat for the South Island Kaka, a Nationally Endangered species, and two other endangered species, but the project manages only small percentages of the total populations of species, hence it has little potential to produce any COPY until it manages a larger proportion of some threatened species' populations.

Comparison of multiple species and single species projects

The results presented in Tables 2 and 3 indicate that five of the six projects studied have contributed to the management of threatened species, either through improving or preventing decline in the species' conservation status. A maximum of three threatened species per site benefited from a project. The success of each project at threatened species management is measured by summing the COPY produced for all known threatened species at each site. It is also indicated by way of the GAIN measure.

Managers of the projects we studied were asked if there were umbrella species present, and they all reported at least one umbrella species present at each site. However few of the species sheltering under an umbrella are classified as threatened species. We have measured the COPY produced by the project during the study period for the threatened species at each site nominated by the project managers. Other species, including those which might benefit from expenditures on umbrella species, are either not threatened and/or are not present in sufficient numbers to be of importance in this context. Increases in population numbers of those species may provide value but the expenditures do not contribute significantly to their conservation status. Although we have measured the status of only a few of the array of species at each site, the total COPY produced provides a valid indication of the overall contribution of each project to the conservation of threatened species. This result is of considerable significance as it greatly reduces the information required for evaluation of multiple species projects.

The PV of costs per discounted COPY reported in Table 4 can, with caution, be compared with the PV of costs per PV of COPY reported in Cullen et al. (2001: Table 7). Cullen et al. (2001) also use a quadratic function to measure output from programs, but their measurement scale is based on seven categories rather than a continuous scale as used in the present research. The impact of using the categorical scale is the likelihood that the measurement of output produced by projects, and so their cost effectiveness, will be underestimated because the seven category scale is too coarse to detect small gains in species status. Recognizing those caveats, it is notable that eight single-species programs (Cullen et al. 2001: Table 3), have achieved greater success in the conservation of threatened species (mean COPY of 1.13) than the six multiple-species projects included in this study (mean COPY of 0.79 at 6 percent discount rate). The mean cost effectiveness ratio of the single-species programs (cost per COPY at a 6 percent discount rate) is $645 482, only 28.6 percent of the weighted mean cost per COPY for the six multiple species projects which we have studied ($2 249 114 per COPY at a 6 percent discount rate). We conclude there is no evidence from the projects and for the time period we have studied, indicating that multiple-species projects have either success, or cost effectiveness advantages over single-species programs in the recovery of threatened species.

The expectation that Mainland Habitat Island projects will have relatively high costs and returns (Saunders 2000; Saunders and Norton 2001) is only supported by the data on costs. The three Mainland Habitat Islands have a mean annualized cost of \$314 658, double that of the three offshore islands (\$154 110). However the three Mainland Habitat Islands are less successful in the conservation of threatened species (mean COPY 0.44 at 6 percent discount rate) than the three offshore islands (mean COPY 1.15 at 6 percent discount rate), and are less successful than eight single species programs in Cullen et al. (2001: Table 3) (mean COPY 1.13 at 6 percent discount rate). These results are in accord with the results reported by Boersma et al. (2001) who found that U.S. species in single-species recovery plans were four times more likely to be improving in conservation status than were species included in multiple-species recovery plans.

Our analysis focuses on measuring the success and cost effectiveness of the projects for threatened species conservation. As already pointed out, however, the conservation of threatened species is not the only objective of the six projects. Each of the projects may contribute to improved threatened species management at multiple sites through insights gained from research by management. Focusing directly on the six projects, Little Barrier Island, Maud Island and Hurunui have a PV/COPY of less than \$1.5 million. Each of these projects manages a significant proportion of the total population of at least one threatened species. Tiritiri Matangi and Rotoiti projects by comparison, manage only small proportions of the total populations of the threatened species and this restricts their ability to significantly improve the status of those species. Tiritiri Matangi has a cost per COPY (at a six percent discount rate) more than forty-six times greater than the cost per COPY for Little Barrier Island, and over 478 times greater than the cost per COPY of the most cost effective single species program in Cullen et al. (2001: Table 7). This result occurs because of the high costs of the project which include advocacy and education activities and the small contribution to improving species' progress achieved at Tiritiri Matangi. River Recovery provides management for a high proportion of at least four threatened species but it provides a smaller contribution to their conservation status than does the more focused Black Stilt recovery program.

Conclusion

We have shown how success and cost effectiveness can be measured for six multiple-species projects using relatively simple, low cost techniques. Project success can be measured by comparing the conservation status of threatened species present at a site, to the threatened species status without the project, using a conservation status continuum linked to the DoC Threat Classification System. Measurement of the output for threatened species conservation from projects during a study period is accomplished by calculating numbers of COPY produced through management of each threatened species present at a site. Total output for a project during a study period is the sum of the COPY produced from threatened species present at a site.

The Present Value of costs of projects can be compared to numbers of discounted COPY produced to allow cost effectiveness calculations to be completed. Because the DoC classification system is linked to the IUCN classification system, the evaluation approach can be applied internationally.

The past success and cost effectiveness of projects may be useful if imperfect guides to their future success and cost effectiveness. Project managers and decision makers can use the techniques reported in this paper to calculate past success and cost effectiveness and, with caution, project likely future success and cost effectiveness of projects. Those projections should provide valuable information to aid decision making and project selection. A trial is needed to test how successfully and in what circumstances reliable projections can be made of project success and cost effectiveness.

Three sites, each with a high percentage of at least one threatened species present, achieved greatest success for the conservation of threatened species by significantly improving the status of at least one species compared to its 'no project' status . Sites lacking a high percentage of at least one threatened species contribute little or nothing to species conservation. The six projects vary greatly in area, and in expenditures per hectare. Their annualized costs range from $80 000 to $500 000, but their cost effectiveness varies by a factor of at least forty-five. This research found no evidence that multiple-species conservation projects are more cost effective than are single-species programs. Mainland Habitat Island projects with their more intensive monitoring and reporting, and need for ongoing pest control, are more costly, and less productive than are offshore island, and single-species programs.

Abbitt and Scott (2001) have argued that it is not possible to measure effort put into species recovery actions and to measure their success. A recent evaluation of biodiversity projects funded through the Global Environment Facility found that only 17 out of 210 projects had sufficient information to assess the projects' impact on biodiversity Singh and Volonte (2001). We have demonstrated in this paper that Cost Utility Analysis provides a low cost practical methodology for evaluating species conservation efforts. The technique requires collection of information from project managers and species experts on costs and species status followed by some data analysis. Where these data collection and analysis requirements can be met Cost Utility Analysis can provide valuable information for project funders and decision makers.

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Literature Cited

Abbitt, R.J.F., J.M.Scott., J.M., 2001. Examining differences between recovered and declining endangered species. Conservation Biology 15, 1274-1284

Andelman, S. J., Fagan, W.F. (2000) Umbrellas and flagships: Efficient conservation surrogates or expensive mistakes? *PNAS*, *97* (11), 5954- 5959.

Boersma, P.D., Kareiva,P., Fagan, W.F., Clark, J.A., Hoekstra.J.M., 2001. How good are endangered species recovery plans? BioScience 51, 643-650.

Cowan, P., 1992. The eradication of introduced Australian brushtailed possums, *Trichosurus vulpecula*, from Kapiti Island, a New Zealand nature reserve. Biological Conservation 61, 217-226.

Cullen, R., Fairburn, G., Hughey, K.F.D., 1999. Copy: A new technique for evaluation of biodiversity protection projects. Pacific Conservation Biology 5, 115-123.

Cullen, R., Fairburn, G., Hughey, K.F.D., 2001. Measuring the productivity of threatened species programs. Ecological Economics 39, 53-66.

Dawson, D., Shogren, J.F.,. 2001. An update on priorities and expenditures under the Endangered Species Act. Land Economics, 77, 527-532.

Department of Conservation and Ministry for the Environment, 2000a. New Zealand's Biodiversity Strategy, DoC/MfE, Wellington. Also available at http://www.biodiv.govt.nz/

Department of Conservation and Ministry for the Environment. 2000b. Restoring the dawn chorus. Department of Conservation, Wellington.

Department of Conservation. 2001a. Threat classification system. Department of Conservation, Wellington.

Department of Conservation. 2001b. The New Zealand Biodiversity Strategy. Summary of achievements during 2000-2001. Department of Conservation, Wellington.

Department of Conservation, 2002. New Zealand threat classification system lists. Department of Conservation, Wellington.

Doerksen, H., Leff, C.S., Simon, B.M., 1998. Policy goals for endangered species recovery. Society and Natural Resources. 11, 365-373.

Drummond, M., Torrance,G.H., Mason, J., 1997. Methods for the economic evaluation of health care programs, 2nd ed. Oxford University Press, Oxford.

Engeman, R.M., Shwiff, S.A., Constantin, B., Stahl,M., Smith, H.T., 2002. An economic analysis of predator removal approaches for protecting marine turtle nests at Hobe Sound National Wildlife Refuge. Ecological Economics. 42, 469-478.

Hughey, K.F.D.,Cullen, R., Moran, E.M., 2003. Integrating economics into priority setting and evaluation of conservation management. Conservation Biology. 17, 93-103.

Hyde, W. F., 1989. Marginal costs of managing endangered species: the case of the red-cockaded woodpecker. Journal of Agricultural Economics Research. 41, 12-19.

IUCN. 2001. IUCN red list categories: Version 3.1. IUCN, Gland.

James, A.N., Gaston, K.J., Balmford, A., 1999. Balancing the Earth's accounts. Nature 401, 323-324.

Kanze, E., 2000. Island of lost birds: New Zealand triumphs in the rescue of endangered species. Wildlife Conservation 103, 56.

Molloy, J., Davis, A., 1994. Setting priorities for the conservation of New Zealand's threatened plants and animals. Department of Conservation, Wellington.

Montgomery, C., Brown, G., Adams, D.M., 1994. The marginal cost of species preservation: The Northern Spotted Owl. Journal of Environmental Economics and Management 26, 111-128.

Montgomery, C., Pollak, R.A., Freemark, K., White, D., 2000. Pricing biodiversity. Journal of Environmental Economics and Management. 38, 1-19.

Polasky, S., Solow, R.A., 1999. Conserving biological diversity with scarce resources. In: Klopatik, J., Gardner, R., (eds). Landscape ecological analysis: issues and applications. Springer-Verlag, New York, pp. 154-174.

Saunders, A. 2000. A review of Department of Conservation mainland restoration projects and recommendations for further action. Department of Conservation. Wellington.

Saunders, A., Norton, D.A., 2001. Ecological restoration at Mainland islands in New Zealand. Biological Conservation 99, 109-119.

Singh, S., Volonte, C., 2001. Biodiversity program study. Global Environment Facility, Washington, DC. Available from www.gefweb.org/resultsandimpact/monitoring_evaluation/evaluationstudies/biodiv_program_study.pdf (accessed February 2004).

Tear, T.H., Scot, J.M., Hayward, P.H., Griffiths, B., 1995. Recovery plans and Endangered Species Act: are criticisms supported by data? Conservation Biology 9, 182-192.

Towns, D.R., Simberloff, D., Atkinson, A.E., 1997. Restoration of New Zealand Islands: redressing the effects of introduced species. Pacific Conservation Biology. 3, 99-124.

US Fish and Wildlife Service. 1990. Report to Congress: Endangered and threatened species recovery program. US Fish and Wildlife Service, Washington.

Weitzman, M., 1998. The Noah's Ark problem. Econometrica, 66, 1279-1298.

World Economic Forum. 2002. 2002 Environmental Sustainability Index. Available at: http://www.ciesin.org/indicators/ESI/

Table 1. Conservation Status Continuum

Department of Conservation threat category	Range on continuum
Not Threatened (NT)	0.99 to 1.00
At Risk – Sparse (S)	0.95 to 0.98
At Risk – Range Restricted (RR)	0.87 to 0.94
Chronically Threatened – Gradual Decline (GD)	0.76 to 0.86
Chronically Threatened – Serious Decline (SD)	0.62 to 0.75
Acutely Threatened – Nationally Vulnerable (NV)	0.45 to 0.61
Acutely Threatened – Nationally Endangered (NE)	0.24 to 0.44
Acutely Threatened – Nationally Critical (NC)	0.01 to 0.23
Extinct[1] (E)	0.00

[1] A taxon that is extinct in the wild but occurs in captivity or cultivation is Nationally Critical and qualified with the letters EW (Extinct in the Wild).

Table 2. The six multiple species projects

Project and location	Area (ha)	Start year	Status	Ecosystem	Goals – project success (%)
Offshore islands					
1. Little Barrier Island Hauraki Gulf North Island	2,817	1896[2]	Nature Reserve	Intact kauri and beech forest	Protection of ecosystem – 60 Endangered species conservation – not known
2. Tiritiri Matangi Hauraki Gulf North Island	218	1984[2]	Scientific Reserve	Removed broadleaf forest	Restoration of ecosystem – 99 Endangered species conservation – 90 Advocacy and education – 100
3. Maud Island Marlborough Sounds South Island	320	1975[2]	Scientific Reserve	Partly intact kohekohe forest Degraded wetlands	Endangered species conservation – 50 Community restoration – not known
Mainland islands					
4. Rotoiti Nelson Lakes South Island	825	1997	National Park	Degraded beech forest	Protection and restore ecosystem – 70 Community restoration – 5 Advocacy and education – 80
5. Hurunui North Canterbury South Island	12,000	1995	Forest Park	Degraded beech forest	Protection and restore ecosystem – 35 Predator and pest control – 80
6. River Recovery Mackenzie Country South Island	11,000	1991	Crown & private land	Degraded braided rivers Degraded wetlands	Protection and restore ecosystem – 75 Endangered species conservation – not known Advocacy and education – not known

[2] Project evaluated from 1987 when the Department of Conservation was established.

Table 3. Threatened species conservation from the projects (number of COPY and Gain)

Project and species	Conservation status 2002[3]	Population at site 2002 (% of total)	Gain (2002)	COPY
1. Little Barrier Island			**0.36**	**2.99**
N.I. Kokako (*Callaeas cinerea wilsoni*)	NE	20	0.10	0.55
Northern Tuatara (*Sphenodon p. punctatus*)	S	>1	0.00	0.00
Stitchbird (*Notiomystis cincta*)	RR	96	0.19	1.39
N.I. Saddleback[4] (*Philesturnus carunculatus rufusater*)	RR	35	0.07	1.05
N.I. Brown Kiwi (*Apteryx mantelli*)	SD	>1	0.00	0.00
Kakapo[4, 5] (*Strigops habroptilus*)	NC	0	0.00	0.00
Woodrose (*Dactylanthus taylorii* Hook.f.)	GD	>1	0.00	0.00
2. Tiritiri Matangi			**0.03**	**0.15**
N.I. Saddleback (*Philesturnus carunculatus rufusater*)	RR	13	0.00	0.00
Stitchbird (*Notiomystis cincta*)	RR	2	0.02	0.06
Brown Teal (*Anas chlorotis*)	NE	>1	0.00	0.00
Takahe[4, 5] (*Porphyrio hochstetteri*)	NC	8-9	0.01	0.09
N.I. Kokako[4] (*Callaeas cinerea wilsoni*)	NE	>1	0.00	0.00
Little Spotted Kiwi[4] (*Apteryx owenii*)	RR	3	0.00	0.00
3. Maud Island			**0.30**	**2.38**
Maud Island Frog (*Leiopelma pakeka*)	NE	100	0.13	1.21
Striped Gecko (*Hoplodactylus stephensi*)	S	45	0.13	0.87
New Zealand Pigeon (*Hemiphaga novaeseelandiae*)	GD	>1	0.00	0.00
Takahe[4, 5] (*Porphyrio hochstetteri*)	NC	7	No data	No data
Kakapo[4, 5] (*Strigops habroptilus*)	NC	15	0.00	0.00
Cook Strait Giant Weta[3] (*Deinacrida rugosa* Buller, 1871)	RR	33	0.04	0.30
4. Rotoiti			**0.00**	**0.00**
S.I. Kaka (*Nestor meridionalis septentrionalis*)	NE	>1	0.00	0.00
Yellow-crowned Parakeet (*Cyanorhamphus a. auriceps*)	GD	>1	0.00	0.00
Mistletoes	DD	>1	No data	No data
5. Hurunui			**0.20**	**1.28**
Yellowhead (*Mohoua ochrocephala*)	NE	3	0.01	0.14
Great Spotted Kiwi (*Apteryx haastii*)	GD	5	0.00	0.00
Orange-fronted Parakeet (*Cyanorhamphus malherbi*)	NE	75	0.19	1.04
Yellow-crowned Parakeet (*Cyanorhamphus a. auriceps*)	GD	1	0.00	0.10
S.I. Kaka (*Nestor meridionalis septentrionalis*)	NE	>1	0.00	0.00
Mistletoes	DD	>1	No data	No data
6. River Recovery			**0.12**	**0.45**
Black Stilt (*Himantopus novaezelandiae*)	NC	100	0.03	0.07
Black-fronted Tern (*Sterna albostriata*)	SD	60	0.02	0.10
Wrybill Plover (*Anarhynchus frontalis*)	NV	15	0.00	0.00
Robust Grasshopper (*Brachaspis robustus* Bigelow, 1967)	NE	100	0.07	0.28

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[3] See Table 1 for acronyms.
[4] A native species that has been introduced or re-introduced to the site.
[5] A native species that is managed as a single population over more than one site. All of the Kakapo on Little Barrier Island were removed and sent to other sites in 1998, and all of the breeding females and three males were transferred from Maud Island to Codfish Island in 2001. About half of the Takahe on Tiritiri Matangi have been introduced from other sites and half have been bred on the island.

Table 4. Costs (NZ$) and Cost Effectiveness (Present Value per COPY) of Projects

Project	Discount rates (%)			
	0	**3**	**6**	**10**
Little Barrier Island				
Present value of costs	$1 263 326	$982 080	$780 345	$597 636
Annualized costs			$80 347	
Annualized cost/ha			$28.52	
PV of COPY	2.99	2.31	1.83	1.38
PV of costs per PV of COPY	$422 517	$424 836	$427 385	$434 402
Tiritiri Matangi Island				
Present value of costs	$2 315 675	$1 872 589	$1 547 381	$1 237 333
Annualized costs			$159 323	
Annualized cost/ha			$730.84	
PV of COPY	0.15	0.11	0.08	0.05
PV of costs per PV of COPY	$15 437 830	$17 375 570	$19 516 305	$23 123 342
Maud Island				
Present value of costs	$3 277 849	$2 632 676	$2 162 521	$1 717 890
Annualized costs			$222 660	
Annualized cost/ha			$695.80	
PV of COPY	2.39	2.07	1.54	1.20
PV of costs per PV of COPY	$1 374 360	$1 270 350	$1 407 864	$1 429 894
Rotoiti				
Present value of costs	$1 627 514	$1 510 647	$1 408 457	$1 291 118
Annualized costs			$286 424	
Annualized cost/ha			$347.18	
PV of COPY	0.00	0.00	0.00	0.00
PV of costs per PV of COPY	Undefined	undefined	undefined	undefined
Hurunui				
Present value of costs	$1 033 316	$941 976	$863 498	$775 086
Annualized costs			$154 682	
Annualized cost/ha[6]			$25.78	
PV of COPY	1.28	1.15	1.04	0.92
PV of costs per PV of COPY	$807 278	$817 667	$828 510	$843 631
River Recovery				
Present value of costs	$5 063 485	$4 456 670	$3 966 070	$3 447 583
Annualized costs			$502 870	
Annualized cost/ha			$45.72	
PV of COPY	0.45	0.34	0.28	0.21
PV of costs per PV of COPY	$11 252 190	$12 588 988	$14 111 199	$12 266 432
Offshore islands weighted mean present value of costs per PV of COPY	$1 239 936	$1 222 126	$1 301 529	$1 350 897
Mainland islands weighted mean present value of costs per PV of COPY	$4 464 922	$4 637 109	$4 725 777	$4 879 458

[6] Annualized cost/ha actively managed by the project.